

PROCESS AND APPARATUS FOR PRODUCING POLYCARBONATE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a Continuation application of Serial No. 09/940,884, filed August 29, 2001, which is a Divisional application of U.S. application Serial No. 09/790,514, filed February 23, 2001, which is a divisional application of U.S. application Serial No. 09/486,913, filed October 12, 2000, which is an application filed under 35 U.S.C. 371 of International application No. PCT/JP98/05245, filed November 20, 1998.

TECHNICAL FIELD

The present invention relates to a process and an apparatus for producing polycarbonate, which is suitable for producing polycarbonate from diphenyl carbonate and an alcohol such as bisphenol A, etc. as raw materials by transesterification upon mixing with a reaction catalyst and additives such as a color adjustment, etc.

BACKGROUND ART

In a process using vertical agitation reactors as disclosed in "Polycarbonate Resin", page 66, published by Nikkan Kogyo Shinbun, a larger number of agitation reactors are required for continuous production with increasing scale of the facility, rendering the process uneconomical.

From the viewpoint of a model for perfect mixing vessels ganged together in series as an economical apparatus structure, it is effective to use horizontal agitation reactors capable of providing a large number of such perfect mixing vessels.

A spectacle rim-formed polymerization apparatus as disclosed in Fig. 2.49(b), C1-43, C·Engineering section, of Mechanical Engineering Handbook, is a continuous agitation reactor, which can provide ideal extrusion flow characteristics, that is, a large number of perfect mixing vessels as ganged together in series, but the highly

viscous liquid, when treated therein, tends to attach to the surface of the agitator center shaft and reside thereon with increasing liquid viscosity. That is, no sharp residence time distribution function curve can be obtained.

- 5 Its mode is shown by a delta response curve in Fig. 8, which is based on test data on relations between the number of model vessels for perfect mixing vessels as ganged together in series and the residence time distribution function. In the spectacle rim-formed polymerization
10 apparatus, deviation from the theoretical curve occurs around the point where the dimensionless number of time, t/t_0 , exceeds 1.3. This means that a portion of the liquid resides in the dead zone of agitation, resulting in a problem of polymer quality deterioration.

15 DISCLOSURE OF THE INVENTION

An object of the present invention is to provide a process and an apparatus for producing polycarbonate, which can improve the quality of polycarbonate as a polymerization product polymer.

- 20 Another object of the present invention is to provide a process and an apparatus for producing polycarbonate, designed to reduce the investment and operating costs.

- According to one aspect of the present invention,
25 a process for producing polycarbonate is provided, which comprises subjecting diphenyl polycarbonate and an alcohol such as bisphenol A, etc. as raw materials to polycondensa-

tion reaction at elevated temperatures ranging from 200°C to 300°C in vacuum less than or equal to the atmospheric pressure in one or more horizontal cylindrical agitation reactors, as ganged together in series, without any
 5 agitator center shaft, with increasing liquid viscosity from 1 Pa·s to 5,000 Pa·s, thereby continuously producing polycarbonate.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic process diagram showing one
 10 embodiment of the present process for producing polycarbonate.

Fig. 2 is a side view showing one embodiment of the agitation blade structure of a primary agitation reactor.

15 Figs. 3 to 7 are front views each showing embodiments of partition plates.

Fig. 8 is a mixing characteristic diagram showing one example of delta response curve.

Fig. 9 is a characteristic diagram showing one
 20 example of relations between the viscosity and the number of theoretical plates.

Fig. 10 is a characteristic diagram showing one example of relations between the viscosity and the miscibility.

25 BEST MODE FOR CARRYING OUT THE INVENTION

Lattice blade polymerization apparatus is an

agitation reactor having rectangular frames as ganged together without any agitator center shaft, as disclosed, for example, in JP-B-6-21159, which can show a curve along the theoretical values.

5 For continuous treatment of a highly viscous liquid, it is obvious from said fact that agitation blades without any agitator center shaft have a better-miscibility and can contribute to improvement of product liquid quality. Therefore, for continuous production of poly-
10 carbonate from diphenyl carbonate and an alcohol such as bisphenol A, etc. as raw materials with elevated liquid viscosity, it is preferable to conduct polycondensation continuously in one or more horizontal cylindrical agitation reactors, as ganged together in series, without any
15 agitator center shaft, at elevated temperature ranging from 200°C to 300°C in vacuum less than or equal to the atmospheric pressure with increasing liquid viscosity from 1 Pa·s to 5,000 Pa·s.

Fig. 9 shows test data of miscibilities of
20 various horizontal agitation reactors in comparison.

The larger the number of theoretical plates per unit stage, the better the miscibility and the smaller the apparatus size, i.e. the more economical. In Fig. 9, the uniaxial agitation reactor is an agitation reactor without
25 any agitator center shaft, where agitation blades are continuously extended, while keeping the clearance between the blade outer edges and the inner wall of the vessel in a range of 1 mm - 50 mm all over the inner surface of the

vessel. It is obvious from the result of said data that the uniaxial agitation reactor can involve larger numbers of perfect mixing vessels than that of the spectacle rim-formed polymerization apparatus and thus has a better

5 miscibility. Fig. 10 also shows miscibilities. It is obvious therefrom that at a higher viscosity than $400 \text{ Pa} \cdot \text{s}$ - $600 \text{ Pa} \cdot \text{s}$ the miscibility of spectacle rim-formed blades becomes poorer than that of lattice blades. That is, it is obvious from the test data of Figs. 9 and 10 that a

10 horizontal agitation reactor without any agitator center shaft is more effective for treating a highly viscous liquid ranging from $1 \text{ Pa} \cdot \text{s}$ to $5,000 \text{ Pa} \cdot \text{s}$.

Fig. 1 shows one embodiment of a process for producing polycarbonate. In a continuous process for

15 producing polycarbonate from diphenyl carbonate and bisphenol A as raw materials by transesterification, the liquid viscosity will increase with the progress of reaction. Prepolymer having a viscosity of $1 \text{ Pa} \cdot \text{s}$ or higher obtained by the initial polycondensation reaction at

20 the preliminary stage is continuously fed to primary agitation reactor 1 by pump 6. The agitation reactor for this purpose is a horizontal agitation reactor in an agitation structure without any agitator center shaft, as shown, for example, in Figs. 2 to 7. Rotating axes 19 at

25 both ends are connected to end plates 22, respectively, and both end plates are secured to each other by a few reinforcing members 24. A plurality of blade partition plates 10 to 13 having different shapes depending on liquid

viscosity ranges are provided in the vertical direction to reinforcing member 24 between both end plates 22 to prevent the liquid from short pass in the longitudinal direction and arranged at broader and broader distances in proportion to increasing viscosity ranges. Numeral 12 designates an intermediate plate.

Agitation blades 15, 16, 17 and 18 have different blade widths depending upon the liquid viscosity ranges and different numbers of blades provided around the inner wall.

10 Agitation blades are continuously extended and arranged in the longitudinal direction, while keeping small clearances ranging from 1 mm to 50 mm from the inner wall of vessel 50. Rotating axes rotate at a lower speed of 1 rpm - 10 rpm in comparison with a speed of 15 rpm - 20 rpm as used

15 in the case of the polymerization apparatus with spectacle rim-formed blades. As a result, the agitation power can be reduced to a few tenths. Scraper blades 20 and 21 provided on the outer side of both end plates 22, respectively, have a screw function of pushing the liquid back inwardly, while

20 keeping a small clearance from the inner wall of the vessel proper.

The liquid having a viscosity of about 1,000 Pa·s discharged from the primary agitation reactor 1 is fed to secondary agitation reactor 2 by pump 6. The secondary

25 agitation reactor is a biaxial agitation reactor provided with successively linked agitation blades of rectangular frames horizontally and in parallel without any agitator center shaft, as disclosed in JP-B-6-21159. The reaction

further proceeds in this reactor, where the liquid viscosity is elevated to about 5,000 Pa·s, continuously producing polymers.

In both agitation reactors, polycondensation
5 reaction is carried out at elevated temperatures ranging from 200°C to 350°C in vacuum ranging from the atmospheric pressure to 0.1 Torr. Phenol as a reaction by product is discharged from the agitation reactors as overhead vapor to the system outside after condensation in condenser 4.

10 According to another embodiment, the same type as that of primary agitation reactor 1 is used for secondary agitation reactor 2, where blade partition plates having different shapes depending upon the liquid viscosity ranges are arranged at broader and broader distances in proportion
15 thereto. As a result, the agitation power can be further reduced.

According to the present invention, the product liquid quality can be improved by using a horizontal agitation reactor or reactors with successively linked
20 agitation blades without any rotating center shaft. The present invention can also provide a process for producing polycarbonate, which can reduce the investment and operating costs.